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fMRI of Semantic Short-term Memory

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Patient studies suggest that short-term memory (STM) for semantic and phonological information relies on dissociable brain mechanisms. While phonological STM appears to have a limited relationship with language comprehension, semantic STM appears to be important for comprehension, particularly when maintenance of several words is necessary prior to semantic integration.

Previous fMRI work (Hamilton, Martin & Burton, 2009) has demonstrated that maintenance of multiple semantic representations is associated with activation of areas within the left middle frontal gyrus (LMFG) & left inferior frontal gyrus (LIFG). Importantly, areas associated with phonological maintenance and rehearsal are not active in such tasks. The current study attempts to corroborate those data using another task that has often been used to assess semantic and phonological STM in healthy subjects and aphasic patients.

Method

Eleven subjects were visually presented lists of words followed by a probe while being scanned. Subjects indicated whether a probe word was synonymous (semantic) or rhymed (phonological) with any of the items in the list. The maintenance interval between lists and the probe varied between 2s and 8s, which allowed us to determine activation unique to the maintenance and probe epochs.

Results

Data were pre-processed according to parameters provided by the AFNI program afni_proc.py. Separate regressors were constructed for semantic and phonological conditions during encoding, maintenance and probe epochs. Analyses were conducted for the contrasts of semantic vs. phonological maintenance and semantic vs. phonological probe. Contrasts are reported here at a threshold of p=.05.

During the maintenance interval we found significantly greater activation for the semantic compared to the phonological condition centered at MFG (BA 9) and including areas of LIFG (141 voxels). A smaller left inferior parietal area (BA 40) yielded greater activation for the phonological compared to semantic condition (19 voxels).

During the probe interval, we found greater activation for the semantic compared to the phonological condition in a large area (516 voxels) that spanned BA 9 to anterior areas of the LIFG with peak activation in pars orbitalis (BA 47). There was greater activation for phonological compared to semantic conditions in a more posterior aspect of LIFG, including posterior aspects of pars opercularis (78 voxels).

Discussion

The present study corroborates a previous study that reported maintenance of semantic representations activates

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areas along the LMFG and LIFG. In addition, we found anterior LIFG activation (BA 47) at the point where subjects indicated whether a probe word was synonymous with a previous list item. We conclude that maintenance of semantic representations relies on areas of the MFG, while a more anterior area of the LIFG is important for semantic evaluation processes necessary to make synonym judgments and that these areas are distinct from areas active during a phonological version of this task.

References

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